Spring 2021

Effects of Artificial Enrichment on Western Lowland Gorilla (Gorilla gorilla gorilla) Activity Budgets

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Effects of Artificial Enrichment on Captive Western Lowland Gorilla (*Gorilla gorilla gorilla)* Activity Budgets

A Thesis

Presented to the Faculty of the

Department of Psychology

West Chester University

West Chester, Pennsylvania

In Partial Fulfillment of the Requirements for the

Degree of

Masters of Science

By

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May 2021

Dedication

I would like to dedicate this project to past, present, and future species who have the desire to live life to its maximum potential and if they cannot speak for themselves, may others recognize their plight and support them.

Acknowledgments

Completing this project and thesis would not have been possible without the guidance of my thesis advisor, Dr. Rebecca Chancellor. She allowed me to follow my own independent project while supporting me fully in every idea I had. I am thankful that I took the chance with my own independent ideas and that she was able to help me solidify them into this thesis. In addition to my primary advisor, Dr. Rundus and Dr. Kumar have helped me through the final stages of my thesis by reading drafts and making sound suggestions that deserve recognition. Without outside help, my research would have faultered and lost gumption.

I would also like to acknowledge fellow past and present Gorilla Behavior Lab members and one volunteer collecting data constantly: Madeline Vandevere, Mackenzie Holm, Taylor Stuart, Sarah Kilburn, Jennifer Ryan, Christina Pavia, Lorri Fechtman, and Maxwell Herbst. Without the help of lab members, the data would not have been collected and our collaborative ideas would not have come to fruition.

One large aspect of this research was the Philadelphia Zoo. I need to acknowledge the great impact it has on students and the people of the community. Without it, many individuals like me would not of had the opportunity to take real-time data, so it was very lucky to have them in our community.

Lastly, I need to include the individual who has pushed me to pursue graduate education even when things may not have always gone how I imagined they would, and that is Matt Price. Without his support, encouragement, and stability I would not have made it this far. Thanks so much for being there for me when I needed someone the most.

Abstract

The benefits of enrichment and proper husbandry protocols and their applicability in wildlife research have been important topics of zoological research. Examining activity budgets of various species throughout zoological facilities reap biological, educational, and conservation benefits. We collected data on the behavioral responses of five western lowland gorillas (*Gorilla gorilla gorilla)* (1 adult male, 2 adult females, 2 infants/juveniles) to a novel climbing structure in the outdoor enclosure at the Philadelphia Zoo. Over a period of 53 nonconsecutive months, we conducted 30-minute focals with 2-minute scan samples on the gorillas (488 total observation hours). We recorded the frequency of behaviors for each gorilla (e.g., playing, foraging, traveling, resting), variations of those behaviors between indoor and outdoor, general outdoor use, and general climbing structure usage. Our results suggest that, on average, the troop increased general outdoor usage by 37%, indoor foraging by 11.4%, and outdoor regurgitation and reingestion by 19%. The troop also decreased outdoor foraging by 17.2% and overall sedentary behaviors by 21.5%. Zoological facilities invest in enrichment, with the hope of satisfying captive species' biological needs. In addition, our data suggest that the novel climbing structure at the Philadelphia Zoo provided an important enrichment opportunity for specific gorillas, while it may not have been particularly useful for other gorillas, suggesting there are individual differences. Additional comparisons at other zoos would expand this research and further offer critical insight into the enrichment needs of captive gorilla populations.

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Chapter 1: Introduction

Providing proper ample care for captive animals can lead to immediate and specific benefits. Such efforts are aided by the development of welfare protocols (e.g., formulation of zoological standards (AZA, 2021), development of enrichment strategies (Quirke & O' Riordan, 2011; gorillassp.org), and maintenance of wild animals (gorillassp.org). Clubb and Mason (2003) suggested proper care and husbandry techniques are necessary to identify adequate enclosure space and enrichment tools. Quirke and O' Riordan (2011) and Clark et al. (2019) defined enrichment as a technique to improve biological, physiological, and psychological aspects of a captive species' wellbeing evaluated through activity budgets and or the presence of abnormal or stereotypic behaviors. Stereotypic behaviors have been categorized as coping methods, or something done out of frustration (Mason, 2006). Similar to human necessities for living, non-human primates require similar levels of stimulation to prevent abnormal behaviors or increase species-specific behaviors (e.g., socialization, foraging, grooming; Van Metter et al., 2008).

Western lowland gorillas are a part of the great ape family that requires cognitively complex enrichment because of their superior intellectual abilities (Russon, 1998). This presents a challenge in creating sufficient enrichment items and tools, and therefore it is imperative to assess items as they are currently being used (Ross & Lukas, 2006). Enrichment research has progressively found weaknesses of earlier attempts at gorilla enrichment. For example, Clark et al. (2019) created technology-based enrichment tools for the complexities of gorilla intelligence, which successfully intrigued captive gorillas and rewarded them for accurate completion of a puzzle feeder. Thus, the trend of enrichment for cognitive complex species such as gorillas has gone in the direction of technology-based tools, something that needs to be further evaluated for their usefulness for this species.

The importance of enrichment programs for any species' life is as valuable as food and shelter (AZA, 2021) and by evaluating the effectiveness of enrichment materials, the longevity of survival and quality of life could be improved for the captive animals. Importantly, these analyses pertain to the five main goals of the gorilla's Species Survival Plan (SSP). According to the Association of Zoos and Aquariums (AZA), specific SSP goals for western lowland gorillas strive to protect the health of captive populations, advance husbandry and care protocols, educate the public, and collaborate with organizations to maintain standards for wild animals (AZA, 2021). In addition to the SSP, the International Union for Conservation of Nature (IUCN) Red list recognizes western lowland gorillas as a critically endangered species because of climate changes, poaching, habitat destruction, and disease (IUCN.org, 2021). Based on this information about the fragile state of wild populations of gorillas, zoological facilities must acknowledge the important role of maintaining healthy captive populations. However, the importance of enrichment in captive settings has historically been overlooked, despite its acknowledgment in the Animal Welfare Act in 1966 (Pub. L. 89-544). With growing threats to western lowland gorillas, captive populations are important to prevent their further decline in wild populations.

The general purpose of this study was to evaluate the activity budgets of a captive population of western lowland gorillas at the Philadelphia Zoo based on the presence of a novel climbing structure in the outdoor enclosure. The outdoor enclosure consisted of a dead tree, a small tree stump, and the climbing structure. Before the installation of the climbing structure, the enclosure was not enriched with any other materials; it only consisted of a second larger dead tree located where the climbing structure is now located.

The western lowland gorillas have unique needs and by considering their biology, physiology, and psychology, zoological facilities can facilitate their adaptation by making their residence an enriched complex habitat. An examination of the climbing structure provides a benchmark for research on enrichment for assessing the Philadelphia Zoo’s overall maintenance of their captive animals. An opportunity to evaluate the structure’s influence on a captive population is usually limited because of habituation. Goodyear and Shultze (2015) found elephants, which have similar cognitive abilities as primates, habituated quickly to various sound trials and suggested that randomized presentation of auditory stimuli may lead to better results. Thus, the potential for habituation for captive gorillas necessitates the immediate analysis of the enrichment before the troop becomes habituated to the structure.

The present study examined the adaptability, unique needs, and activity budgets of captive western lowland gorillas based on observations of gorilla behavior following the introduction of the novel enrichment structure. Based on previous research, it was predicted that the troop would: (a) increase their usage of the outdoor enclosure (location of the climbing structure), (b) increase outdoor foraging, (c) decrease overall sedentary behaviors, (d) decrease regurgitation and reingestion, and (e) show a juvenile preference in the climbing structure over the adult gorillas.

Chapter 2: Literature Review

Lowland Gorilla Overview

The western lowland gorillas have been extensively researched for many different purposes. Any research about their wellbeing and advancement needs a baseline of species-specific and social behaviors and requires the general dissemination of their characteristics and physiological needs. Below is a brief review of their developmental and physical characteristics.

Developmental milestones found in humans are also found in the western lowland gorillas, albeit with different timelines and physiology (Matsuzawa, 2007). Maple and Hoff (1982) observed 65 gorilla births and found that infancy lasts roughly 3 years with an infant mortality rate of 34%. Knowing when gorillas become sexually active is important to infant research because as they develop, biological transitions affect behaviors, much like puberty and adolescence in humans (Pfaff et al., 2004). It is important to know the typical age of transition and how it affects their overall cohort. The average age of sexually active female gorillas and males are 7-8 years old and 16 years, respectively (Watts & Pusey, 1993). Wild females in a cohort typically have their first offspring at age 9, paralleling the development of male gorillas. This difference in sexually active ages and sex differences can explain behavioral differences as well. Sexually mature gorillas influence the behavior of their cohorts inasmuch as females are more prone to accepting sexual and social behaviors from males than immature females (Watts & Pusey, 1993). Alternatively, females may be passive towards mature males and avoid them at all costs. Research on the age of sexual maturity is useful towards understanding social display behaviors common in cohorts to determine their normative paths of reproduction habits.

The distinct physical characteristics of the western lowland gorilla that sets them apart from other gorillas are their body weight and consistency of hair. Maple and Hoff (1982) stated that there are key features in what establishes the species as western lowland gorillas, including their hair pigmentation is “the presence of a white tuft on youth’s bottom, terrestrial adaptations in the foot, homomorphic incisors, and their social behaviors” (p. 3) Another prominent feature of the wild western lowland gorilla is their weight which can average 350 pounds (Maple & Hoff, 1982; Schaller, 1963). In captive populations, these gorillas can weigh between 500-700 pounds in marked contrast to those living in the wild. Differences in weight may be due to the availability of food and physical activity needed in the wild. Knowing the distinctive features of western lowland gorillas can help understand the species' behavioral development, and how their environment can impact early developmental features and the development of bonds among the troop members.

Juvenile Development

The evaluation of infant play and development of western lowland gorillas is vital for examining behaviors of cohorts that contain an infant or mother or both. This section examines research on the age of independence in the wild versus captivity, play behaviors found in infant lowland gorillas, and potential sex differences. Such research can contribute to research on the captive western lowland gorillas because it can help establish baseline behaviors and identify abnormal behaviors.

Hutchinson and Fletcher (2010) identified the following developmental stages associated with the development of infant independence and behaviors in gorillas: infant, juvenile, adolescent, and adult; these stages are similar to those identified in human development (Smart, 2011). Cataloging the gorillas’ life stages is important for establishing a baseline measurement of typical development that can be used for health evaluations. Watts and Pusey (1993) expanded on the definitions of two of the life stages: juveniles (prepubertal organisms that can survive on their own) and adolescents (postpubertal organisms that are not yet fertile). There is no definitive way of substantiating adolescence, but using the first successful copulation, organism's survival, and fertility measures, a consensus can be formulated.

Hutchinson and Fletcher (2010) defined the age ranges for each developmental phase as follows: Infant (0-3 years), Old infant (3-4 years), Juvenile (4-6 years), Adolescent (6-8 years), and Adult (8+ years), with the median age of independence around 4.5 years (Nowell & Fletcher, 2007). The age of independence in the captive populations is much older than in the wild mountain gorillas, perhaps due to differences in nutrition or predation. Studies suggest that the independence of an infant is also related to the presence of an alpha male, who can drastically influence every member of the troop. Maternal instincts elevate in alertness when the alpha male is proximate to her infant causing greater mother-infant contact for protection resulting in a stronger degree of attachment to the infant and possibly lowering the chance for independence. The degree of independence and weaning of an infant may also be related to the physical size of the infant. Weaning from mother supervision is seen more frequently when an infant reaches about one-third of their adult body mass (Hoff et al., 2005; Kappeler et al., 2003). The age at which the first break of contact occurs, even though only lasting a few seconds, is around 4-5 months of age (Fletcher, 2001)**.** When infants reach the age of 2 years old, mother-infant contact lasts only about 2.5 minutes for every half hour, meaning the rate of mother-infant contact quickly diminishes after 2 years of age. Interestingly, males are more gradually weaned than females.

Hoff et al. (1981) identified the following stages of play behavior in infant gorillas: mother-infant play, solitary play, and social play with peers. The beginning stages of any play behavior start with the mother and continue to be controlled by the mother until social play with peers begins. Mother-infant play involves behaviors such as gently nudging fingers and legs or play-wrestling**.** Those behaviors decrease as the infant begins to explore solitary play. A mixture of solitary play and social play occurs in the fifth month of life, with solitary play including ground slapping, manipulation of objects, and locomotor play. In month 8, social play begins, consisting of play-wrestling and mock biting. This pattern of play fluctuates through the next coming months, most likely due to personal preference or the mother's behavior.

Hoff et al. (1981) suggested sex differences in social play among infants as well. Male gorillas begin social play at month 8, while female gorillas began around month 13. This behavioral difference may be related to the independence of the male developing sooner and to the ability of the mother to control the female infant. Maestripieri and Ross (2004) also found that males exhibit play behaviors more frequently, perhaps because males have an active role in their groups for protecting and defending their cohorts later in life. Meder (1990) found males spend most of the early stages of play engaging in display behaviors such as walking/running, standing stiff, and banging on the glass. There are clear patterns of dominance when males began to develop and become more social. The rate of dominant actions from females tend to be much higher than males in *early* development of 30-50 weeks, but after around 70 weeks there is a role reversal of dominance that remains for the rest of life. It appears that female infants are more attracted to adult males than to adult females, impacting their social behaviors (Maestripieri & Ross, 2004). This may be because the female infants would not have much to benefit reproductively from interacting with other females, thus they are biologically drawn to creating bonds with males. Understanding what impacts the development of an infant gorilla can help forms a basis for what may be expected in normative patterns of behavior.

Activity Budget

An activity budget is the percentage of time a species will spend during their day on foraging, social play, mating, or sleeping. Each activity is based on the basic needs of a species and if it is met through the use of standardized activity patterns reported in previous studies. Gold (1992) found the captive western lowland gorillas engage in activities based on their rearing history, time of day, sex, age, and the complexity of their physical and social environment. He examined eight main nonsocial behaviors found in western lowland gorilla infants: object contact, environmental exploration, mouthing, self-directed behavior, display behavior, solitary behavior, rest, and locomotion. Gold found locomotion, mouthing, and object contact were among the most frequently observed behaviors, encompassing 35% of their overall activities. Infants tend to be more inquisitive about their environment and enclosures than adult gorillas as they spend the majority of their day manipulating and mouthing objects. These behaviors impact the zoo's ability to create novel enrichment because infants can habituate to novel items sooner than their older counterparts.

Masi et al. (2009) compared groups of wild mountain gorillas and western lowland gorillas and reported finding differences in their feeding, traveling, resting, and social activities. They also comment on the importance of having a complex environment and on the availability of food for their activity budgets. As opposed to the wild, in a captive environment, there is no scarcity of food and, therefore, the time spent on foraging behaviors or aggression tends to be low. Remi (1999) reported that overall, differences in activity budgets were based on the change in their diets and the availability of food through fruit-rich and fruit-poor seasons. In fruit-poor seasons, wild females spent more time arboreal, foraging in trees while males remained terrestrial for foraging purposes because their size and physicality limits their ability to climb up certain types of trees. Masi et al. (2009) also point out how arboreal their activity budgets is may be related to the nutritional and biological needs of each sex. Males do not need fruit as much as females because of their advantage in foraging on the ground. This important difference is typically seen in captive populations' arboreal behaviors. A key characteristic of many wild gorillas is that they can show dietary flexibility when needed (Masi et al., 2009). Wild gorillas can conserve their energy and opt for a smaller diet of only certain foods in seasons when ample food is not available. This, in turn, impacts their activities of resting and social behavior because typical active behaviors need appropriate nutrition.

Many behaviors found in wild populations of gorillas are also found in the captive populations. Their normative pattern of behaviors of foraging, resting, playing socially, and sometimes mating are similar, but the frequencies of engaging in such behaviors may be related to keeper attention and the availability of resources (Collins & Marples, 2016). Food is always going to be provided to captive populations, but the way they use food may differ from those living in the wild. Wild gorillas are likely to consume food as soon as they find it, while captive ones may hold onto it for later consumption and enjoyment.

Much like the activity budgets of wild gorillas, the captive ones have also shown certain patterns. These patterns of behavior can be seen by visitors and keepers, but most importantly it is imperative to record and evaluate the behaviors of captive gorillas because of the possibility of undesirable behaviors resulting from being in captivity.

Stress behaviors in captivity

Creating a stress-free environment for captive animals of any species is unrealistic because of uncontrollable factors. Also, the measurement of stress is typically based on subjective observations of zoo attendants. However, according to Chen et al. (2017), the measurement of cortisol levels produces objective evidence of elevated stress, but the surrounding events during the extraction of cortisol may not be stressful. It is worth examining common stressful behaviors, define those behaviors, and what in the environment may trigger those behaviors. It is important to recognize when an animal is experiencing stress and determine what can be done in the environment or through husbandry protocols to delay or prevent those negative behaviors from occurring again. Zoological facilities have an obligation to protect the health and welfare of animals kept in captivity.

Some of the effects of stress on animals cannot be easily observed even by experienced keepers or researchers, especially those that are internal, for example, impaired immune function, gastric ulcers, and impaired growth (Lay, 2000)**.** Keepers should not only examine observable events that cause stress but also suspect the possibility of internal health-related stressors. The effects of internal health-related factors are not easily measured by keepers much like measuring thoughts and emotions in humans (Kagan, 2007). Lay (2000) explained how to categorize types of stress that might not always be the result of typical stressful situations or be the result of obvious stressful events. For example, an animal may experience increased heart rate from copulation, something not usually stressful for animals. He created the term ‘eustress’ for those situations in which the effects of stress are present, but the typical stressful antecedent is not present. For the opposite and very observable stressors, medical exams, and health ailments, the term ‘distress’ is used.

A common stress behavior resulting from distress is fear. Gray (1987) described fear as an emotional reaction to a stimulus that the animal wants to avoid or escape from. Hemsworth and Barnett (2000) observed pig farms and found they showed fear responses to certain observable events and when interacting with humans. Reactions to fear can be freezing or crouching (Hemsworth & Barnett, 2000) in captivity**,** much like the responses to predators in the wild. Neophobia is the fear of novel objects, commonly observed in livestock and captive animals (Gustafsson et al., 2014). This common phobia can be treated through sequential interactions with the feared object or humans. Lay (2000) found agricultural livestock become stressed from social interactions and tight living spaces, something that also occurs in many species in captivity. Munksgaard, et al. (1995; 1997) found cattle avoided rough-handling humans by increasing their flight distance.

Many of the techniques to combat stress and fear responses in animals are individually based. These tactics can be financially beneficial to the zoological institution and worth the added expense of training as needed. Keepers and researchers need to determine what causes stress to the animals and how much it impedes their overall wellbeing, much like what is done in human psychological evaluations. Hemsworth and Barnett (2000) suggested the use of conditioning and habituation to prevent neophobia; both techniques have been used for training animals and in treating humans for phobias (Barrett, 1969). With pre-exposure and conditioning, the keeper gradually introduces the feared item or person to the animal in a systematic way as to not be overwhelming. Brief periods of exposure to humans, livestock eventually will show reduced fear of humans. Jones (1993) found a similar treatment helped treat fears in domesticated chickens. By using systematic displays of a human's hand to the chickens, over time, the chickens did not show fear or stress when a human approached them. A similar solution for conditioning human interactions was to integrate gentle and positive interactions with the animals daily. Hemsworth et al. (1981) found when two groups of pigs were handled, one positively and another negatively for 2 minutes, 3 times per week; the group that was handled negatively showed increased levels of cortisol concentrations and a pronounced avoidance of humans. The positively handled pigs showed no fear of humans and were comfortable when in contact with humans. Prior early exposure to humans positively impacts the way animals react to humans later in their life, a technique which can be applied to reducing fear to novel objects and humans.

Stress is bound to occur in uncontrollable situations, especially when observing certain captive populations; they too have to be handled properly to minimize their stress level. Stress is not ideal for animals because it will affect their overall welfare and quality of life while in captivity. Zoological facilities must ensure welfare standards by limiting the amount of stress on their animals to improve their longevity and their quality of life.

Welfare

Welfare encompasses the entire realm of stability and quality of life of a species. Very early in research, and adapted originally from veterinary medicine (Clegg & Delfour, 2018**;** Dawkins, 2006), welfare science has emerged with many new concepts and ways of improving the standards and well-being of different species. Captive and wild animals can be located at farms, homes of individuals, zoological gardens, or laboratories (Clegg & Delfour, 2018)**,** yet all must have the same standards of care and welfare. The American Association of Zoos and Aquariums (2010) has developed standards that all facilities holding animals must adhere to. The welfare of animals is characterized by emotional states, physical health, and behavior, however, emotional states have not been well researched or suggested as a means of definitive measurement (Salas et al., 2018). Welfare is also considered a "balance between positive and negative experiences" (Spruijt et al., 2001, p. 159)—an animal's welfare in captivity rests on meeting its foraging challenges and keeping it active cognitively and physically. Stress resulting from not meeting the animal's needs is likely to make their lives in captivity miserable. This section will look at how welfare is defined, what aspects of the definition have changed over time, what impacts the welfare of an animal in captivity or in the wild, and lastly, how welfare manifests itself in an animal's behavior or biological features.

Beginning in the 1960s, the animal rights and welfare groups centralized their concerns around slaughterhouses and zoos (Clegg, & Delfour, 2018). As a result, the World Organization of Animal Health (OIE), and thereafter the United States Department of Agriculture (USDA) created a set of standards for the care of animals in all settings, and most recently, The Welfare Quality Project (Salas et al., 2018; Clegg & Delfour, 2018). The Welfare Quality Project's objective standards for measuring aspects of welfare are resource-based or animal-based. Examples of resource-based measures are the physical enclosure dimensions and cleanliness, while animal-based measures are behavioral and health-related. Resource-based practices are mainly used when first evaluating welfare because they are more objective, but in recent years animal-based measures have become more objective and are now primarily used to assess welfare (Clegg & Delfour, 2018; Dawkins, 2006; Whitham & Wielebnowski, 2009; Roe et al., 2011).

Grandin (2010) provided an in-depth perspective of slaughterhouses and farms while conducting research on animal welfare. She formulated standards of welfare and examined the care and actual execution of animals in meat plants. Her goal was to ease the process of execution of animals in farms and slaughterhouses, an inevitable process, thus she wanted to make the process as ethical as possible for each animal. A key element of her strategy was to persuade the USDA to adopt her principles to standardize scoring and procedures across facilities. The Welfare Quality Project states there must be: "absence of prolonged hunger and thirst; comfort while resting, thermal comfort and ease of movement; absence of injuries, diseases and pain; and expression of social behaviours, good human-animal relationship and positive emotional state" (Botreau et al., 2007). Some of their standards and rules come from developments that are used widely to measure the effectiveness of an animal's welfare (Clegg & Delfour, 2018; Désiré et al., 2002**;** Paul et al., 2005)**.** It is important to connect all aspects of welfare and to use same set of standards of measurement to ensure the welfare of all species.

Zookeepers and researchers need to use standardized methods to measure all aspects of animal welfare. Like scientists, concrete measurable data provide the most effective information, for example, measurement of cortisol levels. (Clegg & Delfour, 2018; Thomson & Geraci, 1986) Cortisol provides precise levels of stress hormones in the animal, but knowing the surrounding events and behaviors related to those levels is just as valuable. Elevated cortisol levels may result from positive events such as foraging or copulations; thus, an increase in cortisol is not always attributable to something negative. Other objective measurements of welfare are physical health and disease (including sickness and malnourishment) that are physically manifested in the appearance of the animal. One measurement tool, adapted for the Welfare Quality Project, is the measurement of the health of an animal through Body Condition Scoring to examine the physical health of an animal through sickness, scarring, or hair loss. (Clegg & Delfour, 2018; Welfare Quality®, 2009a, 2009b, 2009c; Mononen et al., 2012).

Many environmental factors impact the welfare of animals, one of them being the density of crowds at zoological facilities. Wells (2005) examined the effects of visitor density on the behavior of a troop of captive western lowland gorillas. She found crowd density had a significant impact on 4 out of the 10 captive gorillas, with more resting behaviors during low-density crowds and more aggression during high-density crowds. Many researchers have found similar and contrasting results, which may be due to confounding variables or individual differences (Snyder, 1975; Bonnie et al., 2016; Cook & Hosey, 1995; Fa, 1989; Bloomfield et al., 2015; Bloomsmith et al., 1999**;** Carrasco et al., 2009**;** Hosey, 2005**;** Pizzutto et al., 2007**;** Roder & Timmermans, 2002)**.** Carder and Semple (2008) examined visitor's impact on the gorillas' behaviors, but as a function of their food enrichment. By adding foraging enrichment throughout the day, the average number of visitors did not increase such negative behaviors as self-scratching and visual monitoring, which can mean anxiety and reduced welfare; the study suggests enrichment can mitigate the effects of visitor presence.

Captivity impacts the welfare of certain species with respect to their behaviors and/or their overall health. The transfer from an impoverished enclosure to a more appropriate enclosure may be the solution for some animals, but the act of physically transferring can cause them undue stress. For example, some studies show that transferring baboons to another facility inflicted both positive and negative effects (Bortolini & Bicca-Marques, 2011)**.** Bortolini and Bicca-Marques (2011) observed a variation of behaviors during the time of transition. They observed that eventually after the initial shock of moving, the baboons increased grooming behaviors and decreased self-directed stress behaviors. Clegg and Delfour (2018) and Waples and Gales (2002) also found that social isolation and changing relationships with humans, and negatively impacted the welfare of animals, causing a loss of appetite. The differences in baseline behaviors before and after any transfer or change of enclosures are important to evaluate the after-effects of the transfer. A more enriched environment gives more control through increasing their choice of activity, thus improving their wellbeing (Bonnie et al., 2016; Kurtycz et al., 2014). Enclosure enrichment has a positive impact on the welfare of an animal.

Captive and wild animals have behavioral, cognitive, and physiological similarities. It is easier to measure welfare in captive animals because of very controlled conditions, but measurement of wild animals is difficult, but still important to understand for species welfare.

Progress is being made in the emerging field of wild animal welfare, for example, in understanding the effects of pollution on marine wildlife. Similar to the standards proposed for the captive animals, the International Whaling Commission (IWC) created a Five Domains Model based on the model for captive animals (Clegg & Delfour, 2018; Butterworth, 2017b)**.**

As discussed before, the presence of visitors can have a major impact on the captive animals, much more than what seems possible since there is no physical interaction. Evaluating the effects visitors have on captive animals is important for zoological facilities to identify and implement more effective conservation, health, and welfare efforts for these animals.

Visitors' perspectives

An aspect of zoological institutes not commonly considered is the visitors' perspectives and their impact on captive animals. The influx of visitors influences zoological funding, animals' behaviors, and research. This section will look at zoos' visitations over time, visitors' views on educational and conservation programs, and more specifically views about the western lowland gorillas.

Zoological foundations and institutes have changed their missions and goals to focus on efforts to conserve and improve the lives of captive animals. Peoples' attitudes turned more positive view when zoos and aquariums ensured the safety and health of captive animals, for example, by the development and implementation of regulations such as by the Association of Zoos and Aquariums (2010). This can be seen presently by fewer protests by many animal rights organizations. This shift of focus to improved conservation efforts and animal husbandry procedures led to improved technology, and thus better enclosures, and to more positive behavioral changes in captive animals (Kisling, 2001).

Many policies created for the welfare of the captive animals began when visitors became aware of the plight of the captive animals and raised concerns. Smith et al. (2012) examined visitors' zoo experiences about educational performances, talks, and interactions with staff and the impact it had on their time at the zoo. They looked at the threshold for the number of environmental requests (e.g. recycling, using products absent of palm oil, donating to certain organization) made by zoo staff to visitors until the visitor's experience was deamed obstructed. Visitors gain valuable information from staff about conservation efforts, consequently, it is important to assess visitors' understanding and reactions for developing conservation and educational programs. The education of the public by a zoo must involve the use of visible animals in teaching them. Visitors most likely will not be interested in saving a species if the species are sleeping and out of view when they visit. Carr (2016) discovered the favored species during a common zoo trip were mammals, with orangutans and other primates being the most favored. The least favored species were reptiles and birds because they were "boring, out of view, smelly, or scary" (p. 74). Superficial features such as appearance and activity level were the most influential aspects of the species. The knowledge of favorites of visitors can help in determining which species to focus on for conservation education and which ones need extra educational efforts and to be made more attractive.

The animals who gain the most positive attention from visitors have the best chances for an educational program for visitors (Carr, 2016). The attention paid by visitors could serve as a signal to ask what attracted them to the animal; is it something they liked or did not like about the enclosure and why. Such interviews can help make improvements in both educational efforts and improving the enclosures. Carr's survey revealed visiting the lowland gorilla was a favorite of the visitors. The reasons for their liking them were not examined, but another zoo, Durrell

Wildlife Park, saw similar reactions to the lowland gorilla and found it may be because of their relatability (Carr, 2016). To receive attention from visitors, keepers need to ensure the health of the animals and the quality of their enclosure. The more attention the species receives from visitors and researchers, the better chance they will receive conservation efforts. For animals that do not receive attention, the ones that are most liked can be used as a model of how the enclosure should look or what behaviors are ideal. Not all features of the gorilla exhibit will transfer to other species, but a model of what makes the enclosure special may help attract visitors.

Zoo History

The extensive research of western lowland gorillas includes captive animals and how they are impacted by their environment and enclosures. This section provides a review of zoo models and structures and an overview of the Philadelphia Zoo's mission.

The establishment of zoos can be traced back to the 17th and 18th centuries, with the first exotic animal collection beginning with Egyptian pharaohs and Chinese emperors (Fa et al., 2011). Kisling (2001) saw a shift from private menageries to public menageries, with an increased number becoming zoological gardens. Educational and technological progress shifted the theme towards improved husbandry procedures and animal care in zoos. Fa et al. (2011) found that the early menageries focused on displays and the diversity of collections, but not on maintaining the health of the captive animals. However, given the public's concern about animal care and rights, the zoos began to focus on conservation and education.

The Philadelphia Zoo states its current mission as follows: "By connecting people with wildlife, the Philadelphia Zoo, American's first zoo, creates joyful discovery and inspires action for animals and habitats" (philadelphiazoo.org, 2021). An earlier prototype of a zoo facility was developed in 1907 by Hagenback, who integrated open enclosures without the use of cages, commonly found in many animal sanctuaries (Fa et al., 2011). Hagenback was one of the first zoologists that advocated for the needs of the captive animals and took into account the 'flight distance' necessary for animals to feel comfortable in their enclosures. Although, Heiner Hediger, a prominent zoological researcher (Kawata, 2016), did not coin the term "enrichment," he was an early zoologist to emphasize it as an important aspect of a captive animal's care and welfare (Fa et al., 2011). He also developed the idea of incorporating natural elements of the animals' true habitat into their enclosure.

Wild versus Captive

Wild and captive animals have differences in their normal daily behavior considering the former group does not worry about adapting to new environments. The section explores the social behaviors of both captive and wild western lowland gorillas and discusses the enclosures, food, and husbandry procedures of the captive ones, and compares them to the natural habitats of their wild counterparts.

McDonald and Vandersommers (2019) observed the structure of a single gorilla exhibit in the 1940s. A captive gorilla was housed with a female gorilla for a short time for companionship, but she soon passed after transfer. The keepers wanted to satisfy his social needs and decided to replace her with other companions. The keepers recognized the gorilla's need for companionship, much like the need found in wild populations.

One of the common social behaviors found in most primates is grooming. This behavior can strengthen the trust and bonds between group members. Harcourt (1979) observed gorillas in the wild and found opposing grooming behaviors between two groups. In one group, the dominant male groomed all females, while in the second group, the sole female groomed by the dominant male also groomed him. Compared to the anecdotal accounts of the captive gorillas at the Philadelphia Zoo, this type of grooming behavior is rarely observed (personal observation). It is possible that the environment plays a large role in grooming behaviors. Harcourt (1979) stated that a high-stress environment may not present the gorillas with opportunities to groom and be social. In captive environments, gorillas have amble opportunities to groom because of the elimination of predators.

Many types of lowland gorilla groups found in the wild are reproductive groups, typically composed of a single silverback, one blackback, and several females. The other common group is a bachelor group, composed solely of adult males (Less et al., 2010)**.** With regards to females and their choice in social groups, Harcourt (1979) found that female gorillas will leave their natal group when they reach maturity, primarily living with non-related females and males for the remainder of their lives. This trend can also be found among the captive animals who usually group with unrelated gorillas living in the same enclosure, except for offspring. Some gorillas at their maturity, depending on their genes, will be transferred to other zoos for involvement in the SSP (Moreno Rivas, 2018).

The diet of wild animals is very different from those living in captivity. Husbandry procedures have shifted to a more natural diet for captive gorillas, attempting to parallel diets in the wild. For example, wild gorillas eat and process various fruits and leaves from an estimated 148 plant species (McDonald & Vandersommers, 2019); such variety is not included in the diet of captive gorillas.

An interesting discovery concerns the mating behavior of the captive gorillas. Captive populations are not able to copulate when they please mainly because of birth control procedures monitored by staff. The keepers follow guidelines for the SSP, which does not allow the gorillas to control their reproductive habits. Mating behaviors in captive gorillas are allowed based on

SSP and their health and behaviors. According to the Management of Gorillas in Captivity (1997), the keepers decide on the use of evidence-based contraceptive methods based on the current needs of an animal. Some gorillas will go through common procedures like vasectomies for males or tubal ligation for females. This establishes the group and allows the keepers to appropriately handle and manage the group**.** One key difference that Harcourt (1979) observed about mating behaviors was that estrous females spent more time near the alpha male of the group than any other male in the group. This behavior occurred because females desire to mate and prefer the alpha male, as opposed to younger male gorillas who provided no immediate benefit to the females. He observed females with young offspring spent more time near the alpha male as well, relating this back to increasing their overall fitness to serve as a paternal caregiver if he was so inclined. Harcourt also observed that the proximity of the infant and alpha male did not remain as the infant grew older.

Interestingly, the ability of the lowland gorillas to move from wild to captivity occurs smoothly, if all aspects of daily living are controlled for. For example, the activities and biological behaviors of the species are not starkly different for the two groups. The captive animals can feel secure in terms of living with added enrichment. The key element is to find appropriate enrichment procedures when caring for captive animals. Much of the research conducted at the Philadelphia Zoo pertains to the environmental enrichment of captive lowland gorillas.

Enrichment

Environmental enrichment (EE) bridges the gap between the captive world of an animal and its biological instincts. The Association of Zoos and Aquariums (AZA, 2020) states that enrichment is “A process to ensure that the behavioral and physical needs of an animal are being met by providing opportunities for species-appropriate behaviors and choices." This section reviews common enrichment procedures and their characteristics and issues related to using enrichment. Enrichment procedures can be categorized as tactical, sensory, or social (Van Metter et al., 2008). Issues that can impact the keepers' use of enrichment are peoples' views, habituation, and lack of supporting research behind certain types of enrichment.

It is important to customize enrichment for specific species to have a positive impact on their daily living. For example, a domestic blackbuck may benefit from a tactile brush or a log installed in their stable (Bono et al., 2016). They compared the extent of use by blackbucks an enrichment brush with a log placed in the enclosure. The majority of blackbucks preferred the log over the brush post, however, there may be individual differences because one blackbuck preferred the brush. It is important to consider each animal's unique specific needs that depend on its sex, rearing history, or age (Quirke & O' Riordan, 2011).

Research on enrichment has discovered many different types that positively benefit the specific species it aims to. More importantly, the welfare of the animal should be considered when creating enrichment. The welfare of an animal could manifest in cortisol levels, reproductive behavior, or lifespan. Public opinion also plays a role in welfare and enrichment because visitors expect the enclosures to look a certain way. Appeasing both the visitors and specific species may not be possible, so keepers must have the animal's wellbeing at the forefront. Using more indigenous features based on the specific animals may benefit the species, but can also depend on an individual animal's preference (Fàbregas, 2012)**.** A more reasonable request would be to use appropriate fixtures or vegetation regardless of what one expects to see in the exhibit. The overall appearance of the enclosure should not be the ultimate deciding factor because it may not meet the needs of the captive animals (Fàbregas, 2012)**.** Much like the enrichment located in the lowland gorilla's enclosure at the Philadelphia Zoo, the artificial aspects of the structure may have been developed to appease the public, since anecdotally, the gorillas do not use the structure freely (personal observation).

Whether the enrichment placed in an enclosure for captive lowland gorillas is effective depends on its ability to provide control and choice for the species. Ogden et al. (1993) stated that enrichment should have some similarities to what is found in the species natural habitat—it should allow for control by the animal and natural social groupings. These aspects of enrichment are vital in maintaining positive well-being for each species because they reflect the biological characteristics that are part of the individual species. One assumption made commonly by zoological institutes is that a larger enclosure will automatically address all challenges that the animals face, but Ogden et al. (1993) stated that it is the quality of the enclosure, not the quantity that matters. For example, many captive gorilla species prefer a certain area of the enclosure for privacy or security, not for the sake of openness or expansion of the enclosure. They found there was an increase in species-specific behaviors and a decrease in abnormal behaviors when the quality of the enclosure and enrichment were taken into account in designing the enclosure. Studies on primates suggest the complexity of the enclosure, including enrichment items and structure do increase the play and reproductive behaviors, thus showing the importance of use in empirically-based techniques (Miller-Schroeder & Paterson, 1989). The importance of using empirically-based strategies was demonstrated by Ogden et al. (1993) who found captive gorillas, preferred flat ground to moderate or steep slopes, which they hypothesized may be due to the topography that they are used to in their natural habitat. Providing flat surfaces and ground in the enclosures have validated Ogden et al.'s findings. To provide for the safety and a sense of security in the enclosure, (Menzel, 1967), a preference for the gorillas, vertical walls, and structures were provided. Studies report the gorillas prefer being closer to walls and vertical structures, possibly because it provides them a sense of security, something they are accustomed to in their natural habitat.

Ogden et al. (1993) reported an interesting finding on how gorillas used the enclosure space for foraging purposes. For most zoological facilities, the keepers want the animals to be visible to the public, and one of the tactics they used is to put food in certain areas of the enclosure. The food is placed in certain areas of the enclosure to lure them to be more visible to the visitors. However, such enticement was not effective in drawing animals to the areas they did not normally use in the enclosure. The gorillas in the study would find the food, but then travel to a secure area they find comfortable to eat their food. This behavior has been observed in many zoos, which used food enticement to make the animals go to a certain area in the enclosure for greater visibility to visitors. At the Philadelphia Zoo, keepers have been observed to place food on top of the newly constructed climbing structure, and when the gorillas find the food, they subsequently climb down from the structure and eat it elsewhere (personal observation). The reasoning behind the limited use of the climbing structure is not understood, it could be an individual preference or it could be due to the presence of infants who are not timid in exploring the surroundings. Overall, the benefits of each structural enrichment component in the enclosure needs to be evaluated by careful observations to make them more effective.

Enrichment aims to encourage species-specific behaviors, foraging, grooming, and social play through appropriate stimuli psychologically or physiologically (French et al., 2018; Claxton, 2011; Shepherdson, 1998). Enrichment should help increase their natural behaviors and decrease their abnormal behaviors by providing the animal with choices to improve their well-being (Claxton, 2011).

Chapter 3: Method

Subjects

Five western lowland gorillas (*Gorilla gorilla gorilla*) at the Philadelphia Zoo were observed from 2015 to 2020. The gorillas consisted of 1 male (Motuba (MO), 36 years old), 2 females (Honi (HO), 28 years old and Kira (KI), 21 years old), and their adolescent offspring (Amani (AM), 4 years old and Ajabu (AJ), 3 years old). Motuba is the father of both adolescents. All observations took place in the visitor's viewing areas.

Enclosures

Two primary enclosure areas, an indoor and outdoor space were used for observations in this research. The gorillas also had a holding area below their indoor enclosure, but since there is no appropriate method to observe them from that area, it was not used in this study. The indoor enclosure dimensions were roughly 40' x 25' x 24' equaling around 785 square feet and had various ropes, scaffolding, climbing platforms, puzzle feeders, and other enrichment items that each gorilla could use. Conversely, the outdoor exhibit, which is accessed through a latch door roughly the size of an adult gorilla, measured approximately 10,000 square feet. The latch door was operated by zookeepers at the beginning of a shift for the gorillas. The door was opened weather permitting, which usually meant the outside temperature was above 40 degrees Fahrenheit. In addition to the natural elements that encompassed the outdoor exhibit, the climbing structure was located in the middle of the area, with a large dead tree parallel to the ground and one other smaller tree stump attached by a rope from the climbing structure. The climbing structure was installed on July 25, 2019, and comprises three platforms each measuring 10' x 10.' The structure is 20'x 14'x 27' and constructed out of white oak, black locust, and cedarwood materials. Periodically, keepers place food, puzzle feeders, and on special occasions treats on the climbing structure.

Data collection

Observations were made throughout 6 years by students in the Gorilla Behavior Lab at West Chester University following training after obtaining approval of data sheets with operational definitions. The pre-installation data of the climbing structure followed the same collection procedures as the post-installation data. All data were collected from viewing areas accessed by the public and were completed during normal business hours of the Philadelphia Zoo. Specifically, each student spent roughly 2 hours at the zoo at a time, completing at least three 30-minute focal scans with 2-minute intervals. Students also varied which gorillas they observed each day by recording on a cumulative calendar shared by the members. For reliability standards, each student was trained by multiple graduate students on their accuracy and through following the operational definitions that were explained before beginning the observations.

Behaviors relating to each gorilla's activity budget were recorded and the location of certain behaviors as well (indoor or outdoor). Behaviors categorized as sedentary were laying down, standing, and sitting because they are primarily done in one location and do not take much effort to complete. Foraging was categorized as when an individual is investigating for, holding, or ingesting food inside the exhibit. Regurgitation and reingestion were categorized as one behavior and defined as an individual expelling food from their mouth and consuming it again, and this behavior usually lasted for 10-15 minutes. Each of these behaviors was then further categorized as being indoors or outdoors, this distinction was defined through their location and movement through the latch door. (See data sheets in appendix).

Descriptive analysis

Frequencies of each relevant behavior were totaled for each individual, location, and whether it was pre or post installment of the climbing structure. Each gorilla had its own totals of opportunities for each behavior. This process was continued until every gorilla had a pre- and post-climbing structure percentage for each indoor or outdoor behavior. For regurgitation and reingestion, only two of the gorillas were included in the data, Honi and Kira because they were the only gorillas ever recorded in performing that behavior.

Chapter 4: Results

Descriptive statistical analyses were performed to examine trends concerning five exploratory expectations (see Tables 1- 9). For each expectation, outdoor behaviors and indoor behaviors were compared before and after the installment of the climbing structure individually for each gorilla. The data included were from the time before the installment of the climbing structure that began in 2015 and continued until the first day the structure was available to the gorillas in 2019 and continued until around 17 months after, to the end of 2020. Any confusing or illegibly recorded data were excluded from the analyses. For analyses, the frequency of engagement in each specific behavior was divided by the total opportunities for that behavior given to each gorilla, and the resulting proportions were converted into percentages. A significant change in percentages for each behavior was regarded in this study as greater than 15%. This standard was also used for the overall percentages found for each specific behavior.

Outdoor enclosure use

The troop's overall outdoor enclosure use increased on average by 37.0%, with the largest increase found in the adult female HO (67.6%) and the lowest increase found in KI (22.5%) (see Table 1), an adult female. HO used the outdoor enclosure most after its installment choosing to be outdoors on 72.0% of the opportunities to go indoor or outdoor. For each gorilla's outdoor use, see Table 1.

Outdoor Foraging

Outdoor foraging had an overall decrease for all group members, excluding the two juveniles, after the installment of the climbing structure. The largest percentage for outdoor foraging was a decrease of 30.8% for KI after the installment of the climbing structure (see Table 2). The overall average change in outdoor foraging, excluding KI, was a change of 10.4% after the structure was installed. This decrease was not substantial enough to suggest the gorillas, excluding KI, changed their foraging habits based on the installment of the structure.

Sedentary behaviors

Two out of the five gorillas (HO and KI) decreased their frequencies of overall sedentary behaviors after the installment of the climbing structure, with an average decrease of 21.5% (see Table 4-6)—a change that is large enough to suggest the difference in behavior was because of the climbing structure. The remaining three gorillas (MO, AM, and AJ) showed a slight increase in overall sedentary behaviors, an average of 9.3%. These data suggest that there was a substantial difference in overall sedentary behaviors for HO and KI after the installment of the climbing structure. The greatest individual change was a decrease of 32.7% of sedentary behaviors after the installment of the structure (KI), a significant change in behaviors.

Specifically, looking at indoor and outdoor sedentary behaviors individually, KI had the greatest change that was also significant, a decrease in indoor sedentary behaviors (23.4%). While the other significant change was found in MO, with a significant increase in outdoor sedentary behaviors (19.6%).

Regurgitation and reingestion

Only 2 out of the 5 gorillas (HO and KI) engaged in regurgitation and reingestion (RR). HO increased her overall RR on average by 7.7% (see Table 7-8). KI conversely, decreased her indoor RR by 14.5% and increased her outdoor RR by 25.0%. The only substantial change is the increase of outdoor RR by KI. Overall, it is worth noting that both gorillas increased their outdoor RR by an average of 19.0%.

Climbing Structure Usage

The frequencies of each gorilla's usage of the climbing structure are found in Table 9. The highest frequencies of the usage of the climbing structure are found within the two juveniles, both collectively taking up 73.2% of the total climbing structure usage. The lowest total for the climbing structure usage was found in MO, with only 8 occurrences of physically using the structure.

Chapter 5: Discussion

The addition of a novel climbing structure suggested an overall significant (15%) increase within the troop in general outdoor enclosure use. There was a slight trend towards decreased outdoor foraging, with Kira having the largest change, and a slight trend in increased indoor foraging (not a significant change to conclude the structure was affecting that activity). The two female gorillas showed a slight trend in decreased sedentary behaviors and only Kira increased her outdoor regurgitation and reingestion (RR) a substantial amount. The total frequency of the climbing structure usage shows there was a strong preference in the juveniles.

Foraging behaviors and outdoor usage are important for the western lowland gorillas' survival when compared to other non-human primates because of their "greater nutritional requirements" (Masi, et al., 2009, p. 98), and are important behaviors for captive animals. On the opposite spectrum of captive animals, sedentary behaviors and RR were examined because of the perceived negative implications for their wellbeing. Newberry (1995) hypothesized that a captive environment elicits an increase in sedentary and stereotypic behaviors because of the elimination of predators and the constant availability of food. Captive animals will most often succumb to adapting to a sedentary lifestyle. Mellen and MacPhee (2001) suggested besides reducing sedentary behaviors solely by using proactive goals. Proactive goals aim to not solely focus on decreasing stereotypic behaviors but additionally aim to increase species-specific behaviors. Thus, this research examined both increases and decreases in certain behaviors.

Outdoor enclosure usage

As predicted, the troop chose the outdoor space more frequently than the indoor space after the addition of the outdoor climbing structure. Besides the immediate physical difference that an outdoor space had on the gorillas (e.g., natural elements, various textures, sounds), the gorillas practiced choice and independence, and other forms of enrichment. A captive lifestyle eliminates the necessity of constantly scanning for predators, thus takes away the natural independence found in wild animals. By providing captive animals with some modicum of choice, they can practice their innate characteristic for survival. Carlstead and Sheperdson (in Moberg & Mench, 2000) stated that there should be some form of choice provided to captive animals to satisfy a biological need to explore.

Specifically, the individual gorillas that chose to use the outdoor space the most were Honi and Motuba, 72.3% and 50.8% of the time, respectively. It is possible that these animals used the outdoor space more frequently (especially Honi) because they perceived the climbing structure as a novelty item in their environment. Other elements present in Honi's surroundings may also have affected her behaviors. For example, the development and growing independence of her infant daughter Amani, the placement of food, or the weather could have all impacted her choices. Honi also had the greatest frequency of outdoor foraging within the entire troop, suggesting that she may be most comfortable compared with others in the troop with novel items or she may be the most food motivated.

Besides the climbing structure, there was no other shelter or physical structure for the gorillas to explore outdoors, thus exploratory behaviors were limited primarily to the climbing structure. Any form of structural enrichment should provide shade, climate control, or hiding spots for captive animals (Sheperdson & Carlstead, 2020), thus this structure may be achieving those goals indirectly. An important aspect of the progression of the outdoor enclosure for the captive lowland gorillas at the Philadelphia Zoo is that there was only a dead tree placed where the structure is now and no other form of physical enrichment. These data suggest the addition of a climbing structure may not necessarily result in the gorillas physically using it; the observed frequencies of using the structure were in favor of only the juveniles but it could be a reason for the troop increasing their outdoor enclosure usage.

Outdoor foraging

It was predicted that foraging behaviors would increase because of the perceived curiosity in the climbing structure and the shelter it may provide. However, the troop did not show significant (15%) changes in their outdoor foraging except in Kira, the younger adult female. Kira had a decrease in outdoor foraging by 30.8%. Two of the remaining gorillas, Motuba and Honi, also decreased their outdoor foraging, but the change on average decreased by 10.4%. Interestingly, the adults of the troop showed a trend of decreased outdoor foraging, while the 2 juveniles increased their outdoor foraging by 7.7%. The increased outdoor foraging by the 2 juveniles may be due to the fact they were still developing and progressing through their infant years as the study continued. These results are the opposite of what Wood (1998) found with her research on the influence of enrichment on captive chimpanzees. Wood concluded that the addition of novel enrichment increased the captive chimpanzees' foraging behaviors, but again this particular group of primates may have other elements in their environment affecting them. Kira may have decreased outdoor foraging because she was no longer comfortable using the outdoor space in the presence of the structure. A follow-up study should look at the time spent outdoors and possibly the proximity of the gorillas to the structure. This would inform the researchers on how interested the gorillas may be in the structure and also if they are only going outside to retrieve food and then going back inside.

Indoor foraging

Excluding the alpha male, the troop showed a slight trend of increased indoor foraging. Increased indoor behaviors were not expected because of the predicted curiosity caused by the outdoor climbing structure that would draw them outside more frequently. Motuba's inclination to decrease indoor foraging may be rooted in his alpha male personality and the individual differences found within the troop. Motuba may have more confidence than the other members of the troop and not be as intimidated by the presence of a novel structure. The troop may have increased indoor foraging because, like previously stated with Kira's decreased outdoor foraging, the troop may not be comfortable outdoors near the structure. A new enrichment item may appear novel for about two months and the troop was well past the point of novelty throughout the data collection. Noting the limits of the study, a complete assessment of the structure may need to be extended for a more long-term study, possibly 5 to 10 years after installing the structure to get a clearer picture.

Sedentary behaviors

Although in this study significant (15%) changes in the time spent sedentary was not observed, the 2 adult females, Honi and Kira, decreased sedentary behaviors after the installment of the climbing structure. The remaining individuals of the group increased their sedentary behaviors slightly by 9.3%. These sedentary behaviors were categorized as laying down, sitting, or standing. The location of sedentary behaviors was not specifically examined in this research because a general decrease in sedentary behaviors may be influenced by no matter where the gorillas were located. The study of sedentary behaviors brings attention to the necessity of providing individualized stimulation for captive animals that may become sedentary or develop routines. Gorillas, much like other non-human primates, require stimulation that is not only in the form of puzzle feeders or climbing structures. Shepardson and Carlstead (2020) stated that enrichment should diversify an animal's environment and give them cognitive challenges not easily achieved through basic shelter.

Regurgitation and reingestion

Regurgitation and reingestion (RR) behavior is a behavior primarily found in captive non-human primates and can be described as the reingestion of recently eaten food (Akers and Schildkraut, 1985). Only 2 out of the 5 gorillas engaged in this behavior, Honi and Kira, the 2 adult females. Interestingly, surveys of various zoos have noted that 65% of their captive gorillas engage in RR, suggesting it is not an abnormal behavior within captive animals. However, this behavior is not found in wild animals, suggesting the origin of this behavior may be boredom or lack of control in captivity (Lukas, 1999).

On average, Honi and Kira increased their overall RR by 7.7%, not a significant change, but when examining outdoor RR, it increased on average by 19.0%. It is therefore possible that the climbing structure placement may have influenced their RR. Specifically, Kira increased her outdoor RR by 25.0% and decreased her indoor RR by 14.5%, suggesting she may have become more stressed after the installment of the structure or she was spending more time outside, thus enacting these behaviors outside. Lukas (1999) has stated that the disparities of captive and wild gorilla RR frequencies may be due to the natural foraging behaviors found in wild animals. She pointed out that wild gorillas spend much more time foraging, thus captive populations are attempting to mimic foraging frequencies by continually eating the same foods. These data also opens up the possibility of personality and individual differences found in gorilla troops, similar to what was found with the alpha male personality. The females in this troop only engaged in RR, suggesting a biological instinct to savor food, or a need to occupy oneself with an activity.

Climbing Structure Usage

The greatest amount of climbing structure usage was observed in Ajabu with 44 instances of being in physical contact with the structure over a period of 16 nonconsecutive months. The rest of the troop's totals for their use of the structure were: 38 (Amani), 12 (Honi), 10 (Kira), and 8 (Motuba). Usage of the climbing structure was overtly present in the juvenile's activity budgets with them taking 73.2% of the frequencies for the entire troop. Even with the high numbers of the juveniles using the structure, their other activities were not nearly as substantial. For example, the average amount of change in outdoor foraging for the 2 juveniles was only 7.7%, not a substantial change. The structure may be a more interesting item for the juveniles than the adults because they are venturing outdoors, but their outdoor activities did not increase. Looking at the overall increase in basic outdoor use, the juveniles increased it by 32.7%. This suggests that they may be going outdoors more based on the placement of the structure.

For future studies, it may be beneficial to focus more on the juveniles and follow their development and comfort level with the structure. Future studies should also examine the specific behaviors exhibited while on the climbing structure. For example, the troop has used the climbing structure for foraging purposes because keepers place food primarily on the structure to encourage its use. However, the gorillas using the climbing structure the most were the juveniles. Therefore, it would be interesting to examine the specific behaviors they engage in while on the play structure.

Chapter 6: Implication

The purpose of the study was to evaluate the activity budgets of captive gorillas based on the addition of a novel climbing structure. The data suggested the troop collectively increased their outdoor enclosure use, decreased their outdoor foraging behaviors, increased indoor foraging, and partially decreased sedentary behaviors and regurgitation and reingestion after the installment of the structure. Prior to the installment of the climbing structure, the outdoor enclosure space was barren; it contained a dead tree stump, so the need to create a more enriching habitat was present. The results of this study suggest that the troop increased species-specific behaviors of using outdoor space, which in-part may be due to the structure. This study raises the possibility animals do not have to physically use the climbing structure to achieve the goals of its installation—it may indirectly satisfy the captive animal's need for curiosity or to have a more complex environment. Zoos can invest in easier and less expensive enrichment items, for example, shaded areas, scented trees, or areas out of the line of view from visitors. This study also provides a greater understanding of how a troop of gorillas that have been housed in captivity exhibit individual differences. Further studies on individual differences may help achieve the long-term goals set out by their SSP.

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Appendix A: Tables 1-9

Table 1

Individual Outdoor Enclosure Use Pre/Post Structure

Individual Gorilla	Percentage of Outdoor Use (Pre-Structure)	Percentage of Outdoor Use (Post-Structure)	Post-Pre
MO	21.1%	50.8%	+29.7*
HO	4.7%	72.3%	+67.6*
KI	17.2%	39.7%	+22.5*
AM	4.8%	41.9%	+37.1*
AJ	17.2%	45.5%	+28.3*

Note. Each gorilla has an independent choice to use the outdoor enclosure space when the option is given by the zookeeper.

*indicates a large change in behavior, >15%.

Table 2

Individual Outdoor Foraging Pre/Post Structure

Individual Gorilla	Percentage of Outdoor Foraging (Pre-Structure)	Percentage of Outdoor Foraging (Post-Structure)	Post-Pre
MO	23.1%	14.2%	-8.9
HO	35.7%	23.8%	-11.9
KI	48.6%	17.8%	-30.8*
AM	2.3%	12.4%	+10.1

AJ	4.2%	9.5%	+5.3

*indicates a large change in behavior, >15%.

Table 3

Individual Indoor Foraging Pre/Post Structure

Individual Gorilla	Percentage of Indoor Foraging (Pre-Structure)	Percentage of Indoor Foraging (Post-Structure)	Post-Pre
MO	21.1%	19.6%	-1.5
HO	18.9%	32.5%	+13.9
KI	25.7%	35.9%	+10.2
AM	5.5%	16.8%	+11.3
AJ	3.0%	13.1%	+10.1

Table 4

Individual Overall Sedentary Behaviors Pre/Post Structure

Individual Gorilla	Percentage of Sedentary Behaviors (Pre-Structure)	Percentage of Sedentary Behaviors (Post-Structure)	Post-Pre
MO	71.2%	80.9%	+9.7
HO	65.6%	55.3%	-10.3
KI	75.3%	42.6%	-32.7*
AM	28.0%	35.5%	+7.5
AJ	28.6%	39.4%	+10.8

*indicates a large change in behavior, >15%.

Table 5

Individual Indoor Sedentary Behaviors Pre/Post Structure

Individual Gorilla	Percentage of Indoor Sedentary Behaviors (Pre-Structure)	Percentage of Indoor Sedentary Behaviors (Post-Structure)	Post-Pre
MO	71.7%	78.7%	+7.0
HO	66.0%	54.0%	-12
KI	65.0%	41.6%	-23.4*
AM	27.5%	33.4%	+5.9
AJ	27.8%	40.2%	+12.4

*indicates a large change in behavior, >15%.

Table 6

Individual Outdoor Sedentary Behaviors Pre/Post Structure

Individual Gorilla	Percentage of Outdoor Sedentary Behaviors (Pre-Structure)	Percentage of Outdoor Sedentary Behaviors (Post-Structure)	Post-Pre
MO	65.6%	85.2%	+19.6*
HO	62.0%	57.0%	-5
KI	47.0%	45.6%	-1.4
AM	37.9%	43.0%	+5.1
AJ	38.2%	37.6%	-0.6

*indicates a large change in behavior, >15%.

Table 7

Individual Indoor Regurgitation and Reingestion Pre/Post Structure

Individual Gorilla	Percentages of Indoor RR (Pre-Structure)	Percentages of Indoor RR (Post-Structure)	Post-Pre
HO	70.0%	72.4%	+2.4
KI	66.3%	51.8%	-14.5

Table 8

Individual Outdoor Regurgitation and Reingestion Pre/Post Structure

Individual Gorilla	Percentages of Outdoor RR (Pre-Structure)	Percentages of Outdoor RR (Post-Structure)	Post-Pre
HO	16.7%	29.6%	+12.9
KI	0%	25.0%	+25.0*

*indicates a large change in behavior, >15%.

Table 9

Climbing Structure Usage

Individual Gorilla	Frequencies of Climbing Structure Usage
MO	8
HO	12
KI	10
AM	38
AJ	44

Appendix B

Gorilla Behavior Focal Scan used for each 30-minute scan.

Observers:
Group Observed - circle one:
(Family, Bachelors, LO only, KA only):
Date:
Time In: Time Out:

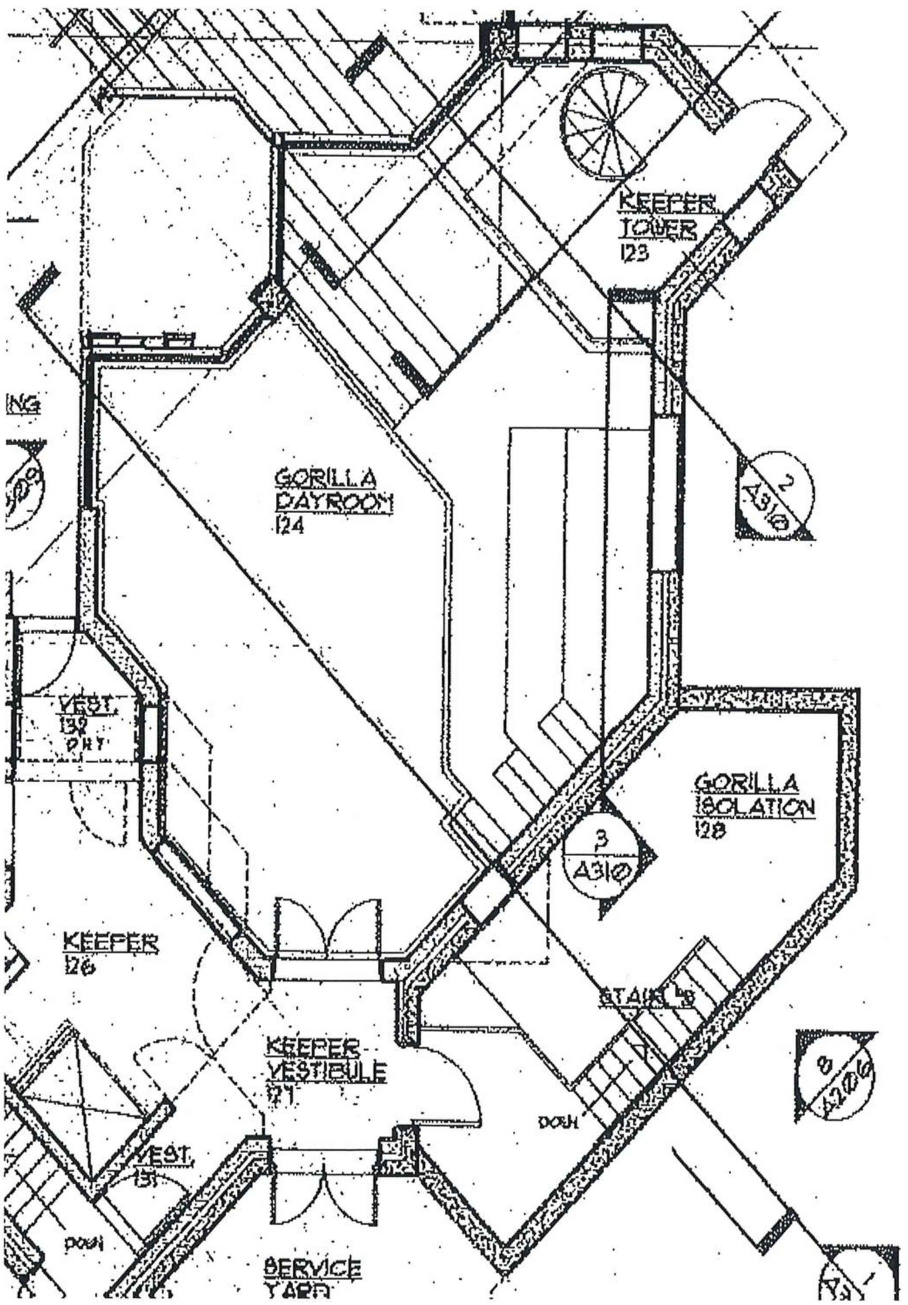
Gorilla Behavior Focal Scan

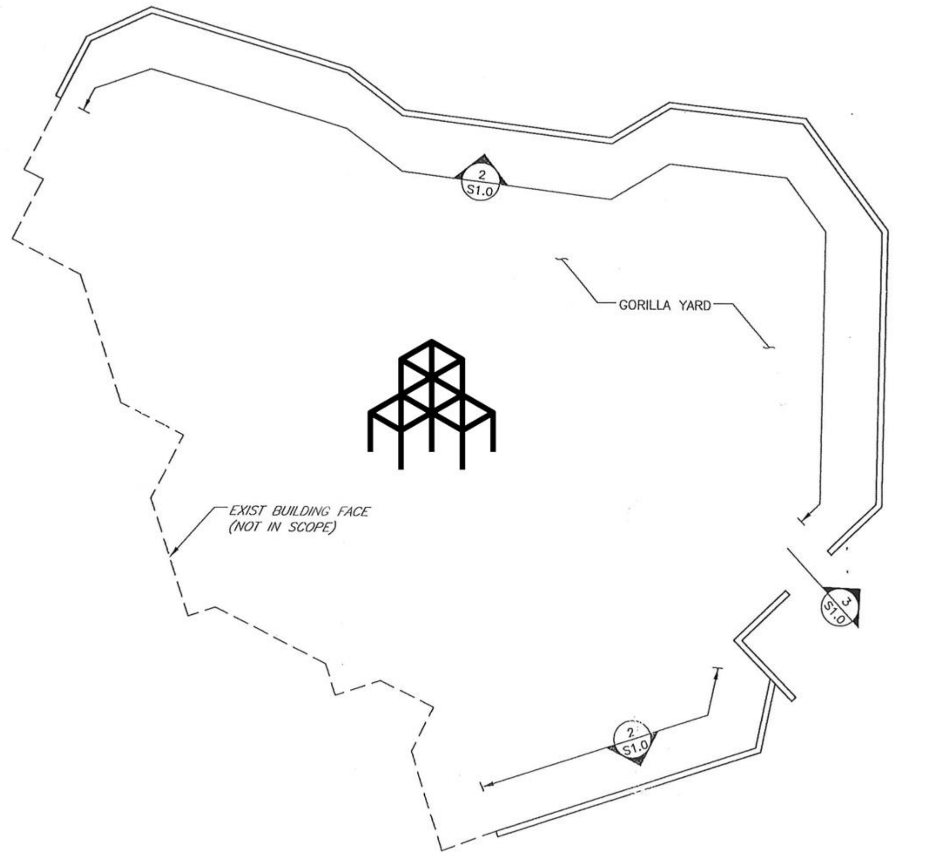
Temperature (Fahrenheit):
Food (Y or N):
Access to which enclosures:

Time	Individual	Location	Arboreal?	Distance to LO	Distance to KA	Distance to MO	Distance to HO	Distance to KI	Distance to AM	Distance to AJ	Activity	Notes
12:10	MO	1	N	N/A	N/A	N/A	P	D	P	D	F	feeding on browse

Appendix C

Layout of the gorilla's indoor and outdoor enclosure, with an approximate pinpoint location of the climbing structure in the outdoor enclosure.





GORILLA YARD WALL PLAN
NOT TO SCALE

N

Climbing Structure

Appendix D

IACUC Approval Form

WEST CHESTER UNIVERSITY

Psychology Department | West Chester University | Wayne Hall
125 W. Rosedale Avenue, West Chester, Pennsylvania 19383 | 610-436-2945 | fax: 610-436-2526
www.wcupa.edu/psych

March 1, 2021

To whom it may concern,

The proposed research by Angela Perretti, to conduct observational research of the captive gorillas at the Philadelphia Zoo, has been determined not to require the submission of an IACUC protocol. This work will fall strictly under the protocols and procedures maintained by the Philadelphia Zoo.

Please feel free to contact me if you have any additional questions.

Aaron Rundus

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